15110 PRINCIPLES OF COMPUTING – EXAM 1A – FALL 2012

Name _____ Section _____

Andrew id _____

Directions: Answer each question neatly in the space provided. Please read each question carefully. You have 50 minutes for this exam. No electronic devices allowed. Good luck!

```
1  _____
2  _____
3  _____
4  _____
5  _____
6  _____
TOTAL  _____
```

1.(14 pts total)   History of computation

(a) (4 pts) Match each item in the left column with the most relevant item in the right column.

not covered in spring '13

Jacquard's loom	_____	1. Electromechanical computer
ENIAC	_____	2. Enigma cipher
Moore's Law	_____	3. Polynomial function
Difference Engine	_____	4. Vacuum tubes
Harvard Mark I	_____	5. First programmer
Grace Hopper	_____	6. Hollerith tabulating machine
Ada Lovelace	_____	7. Exponential function
Alan Turing	_____	8. Debugging

(b) (6 pts) We want to use the method of finite differences to create a table of numbers for the function $f(x) = 5x^2 - 4x + 3$. Compute the necessary difference functions and the initial values for x = 0 for this machine. Then fill in the table for x values from 1 to 3.

$\Delta f(x) =$ _____ x + _____

$\Delta^2 f(x) =$ _____

x	$\Delta^2 f(x)$	$\Delta f(x)$	f(x)
0			
1			
2			
3			

(c) (2 pts)   A byte is _____ bits, so a kilobyte is _____ bits.

(d) (2 pts)   Moore's Law says that the _____ of integrated circuit

chips _____ every 18 months.

2. This problem focuses on expressions and data types.

(a) (6 pts) For each of the following Ruby expression, write down the value that would be output if the expression was evaluated in irb.

40 / 9   _____   15.0 /2   _____

2 * 2 ** 4   _____   15 % 2   _____

6 + 4 * 2 - 1   _____   2 != 2   _____

(b) (2 pts) Write a Ruby function `triangle_area` that takes two parameters h and b, respectively, for the height and base of a triangle, and returns the area of the triangle given by the formula

$$A = \tfrac{1}{2} (\text{height} \times \text{base}).$$

(c) (2 pts) Write a Ruby function `truncated_triangle` that takes height and base parameters (h and b) as input, and computes the area of a triangle that the tip cut off. The tip is also a triangle; its height and base are 10% of the height and base, respectively, of the larger triangle, as shown in the figure. Use the `triangle_area` function in your solution.
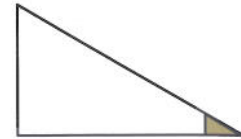
(d) (2 pts)

```
def mystery1(m, n)
    i = 0
    while i <= n-1 do
      i = i + 1
      print i ** m, " "
    end
  end
```

The Ruby function above prints a sequence of numbers. Which of the following is the output of the function expressed in terms of m and n? Circle your answer.

$$1 \quad 2^m \quad 3^m \quad ... \quad n^m \qquad\qquad OR \qquad\qquad 1 \quad m^2 \quad m^3 \quad ... \quad m^n$$

(e) (4 pts) If the print statement was taken outside of the while loop to occur right after the while statement, as shown below, what would the function call mystery2(2, 3) print?

```
def mystery2(m, n)
  i = 0
  while i <= (n-1) do
    i = i + 1
  end
  print i ** m, " "
end
```

_____

(f) (4 pts) Consider the following Ruby function:

```
def mystery3(m, n)
  i = 0
  result = 0
  while i <= (n-1) do
    i = i + 1
    result = result + i ** m
  end
  return result
end
```

What would the value of the variable x be after executing the following assignment statement below?

```
x = mystery3(2,4)
```

_____

(3) (20 pts total) This question focuses on the array data type and iterators.

(a) (6 pts) Assume the following list definition in Ruby using an array.

cars = ["Honda", "Toyota", "Kia", "Chrysler", "Mercedes"]

What would be displayed in `irb` for each of the following Ruby expressions?

cars.length   _____

cars.first   _____

cars[1]   _____

cars.include?("Mazda")   _____

cars.include?("KIA")   _____

cars.each { |x| print x + "*" if x > "Kia"}   _____

this iterator not covered in class by week 4 but you can learn about it in Section 3.4 of EC.

4

(b) (4 pts) Assume the following list definition in Ruby using an array.

a= [1, 2, [3, 4, 5], 6]

What would be displayed in irb for each of the following Ruby expressions?

a.length   _____

a.first   _____

a[2]   _____

a + a   _____

↖ not covered in class as of week 4

(c) (10 pts) Assume the following list definition in Ruby using an array.

a = [2, 4, 6, 7, 8]

What would be returned in irb for if the following Ruby expressions are executed in the given order?

not covered as of week 4

a.collect{ |x| x / 2 }   _____

a   _____

a.select{|x| x.even?}   _____

a.delete_if{ |x| x % 3 == 0 }   _____
    Hint: delete_if is a destructive method in Ruby.

a   _____

4. (20 pts total) This question focuses on looping.

(a) (8 pts) We wish to define a Ruby function `out_of_order` that takes an "almost sorted" list as input and returns the first item that is not in ascending order. The function should return nil if the list is entirely in ascending order. For example, `out_of_order([1, 5, 17, 12, 24])` should return 12, since 12 is less than the preceding item, 17. Complete the following iterative function `out_of_order`.

```
def out_of_order(list)

    index = _____

    while index < _____

        if _____ > _____ then

            return _____

        end

    index = _____

    end

    return _____

end
```

(b) (8 pts) Consider the following recursive algorithm for returning the first item in a list that is not in ascending order, else nil. Complete the recursive definition of `out_of_order`.

1. If the list has fewer than two elements, return nil.
2. If the first element in the list is greater than the second element, return the first element.
3. Otherwise return the result of a recursive call on the tail of the list (i.e., everything beyond the first element.)

```
def out_of_order(list)

    if _____ < 2 then

        return _____

    elsif _____ > _____ then

        return _____

    else
        return _____

end
```

(c) (2 pts) Give an example of a six element list that would be a worst case input for out_of_order.

_____

(d) (2 pts) What is the big O worst case complexity of out_of_order?

_____

5. (20 pts) This question deals with searching and sorting.

(a) (2 pts)

What is the big O complexity of binary search? _____

What is the big O complexity of insertion sort? _____

(b) (6 pts) Fill in the table below to show how binary search would locate the value "e" in the list
["a", "b", "c", "d", "e", "f", "g", "h", "i", "j", "k"]. Use the binary
search algorithm taught in the book and covered in lecture. Note: this table may contain extra rows.

Iteration	Low	High	Mid	list[mid]
1	-1	11	5	f

(c) (6 pts) For each sorting algorithm described below, give its correct name:

- For each input item, find its proper position in the result list and add it at that position.

  _____

- For each position I in the list, find the index of the smallest item at or to the right of position I, and swap `list[i]` with `list[index_of_smallest]`.

  _____

- Organize the inputs into N groups of size 1. Systematically combine adjacent groups to form N/2 sorted groups, each of size 2. Repeat the process, combining adjacent groups of size 2 to form N/4 sorted groups of size 4. Keep going until you have one sorted group of size N.

  _____

(d) (6 pts) Suppose we want to know if all the elements of a list are the same. For example, `all_same([1, 1, 1, 99, 1, 1])` should return false, but `all_same(["f","f","f","f"])` should return true. Here are two solutions. Fill in the missing elements.

```
def all_same1(list)

  sorted_list = list.sort

  if sorted_list[0] == sorted_list[ _____ ] then

    return _____

  else

    return _____

  end

end
```

```
def all_same2(list)

  list.each { |x| return _____ if _____ != list[0] }

  return _____

end
```

What is the big O complexity of all_same1? _____

What is the big O complexity of all_same2? _____

6. (6 pts) This question is based on your readings from the book *Blown to Bits*.

When you print a report using a laser printer, can you assume that no one can tell who printed it? Give a yes/no answer followed by a one sentence explanation.